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Injury risk during different physical activity behaviours in children, a systematic review with bias assessment

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Abstract

Introduction

The current focus on a physically active lifestyle in children puts children at increased physical activity related injury risk.

Objective

To summarize, in a systematic review, the evidence for the injury risk of several physical activity behaviours in 6 to 12 year old children.

Methods

An electronic search was performed in three databases (Embase, PubMed and SPORTDiscus). Inclusion criteria were: age 6 to 12 years; report on injuries related to overall physical activity, active commuting, unorganized leisure time physical activity, physical education and/or organized sports; incidence rates expressed as injuries per hours of physical activity; and published after 1 January 2000. Risk of bias was assessed for all studies included.

Results

Eight studies were included. The risk of bias assessment resulted in two studies with a score that was higher than 75%; risk bias of those two studies was considered low. Medically treated injury incidence rate was reported to be between 0.15 and 0.27 injuries per 1,000 hours of physical activity. The absolute number of injuries related to unorganized leisure time physical activity was higher than the absolute number of injuries reported in organized sports. The respective injury incidence rate expressed per 1,000 hours exposure was, however, generally lower during unorganized leisure time than during organized sports. Reported injury incidence rates related to active commuting were comparable with those for unorganized leisure time physical activity. Conflicting injury incidence rates were reported for physical education. Subgroup analysis suggested that girls and children with low habitual levels of physical activity are at increased injury risk. A limitation of the review is that no standard bias assessment was available for this specific context.

Conclusions

Children are at an inherent injury risk while participating in physical activities. Most injury prevention efforts have focussed on the sports setting, but these results suggest that many children sustain an injury during unorganized leisure time physical activities.

Introduction

The detrimental effects of physical inactivity on the health of youth are nowadays well recognized[1]. In children aged 5 to 17 years, one daily hour of moderate to vigorous intensity physical activity is recommended to prevent overweight as well as a variety of chronic conditions[2]. Unfortunately, many children fail to reach this recommended minimal dose of daily physical activity. Data from the '2009-2010 Health Behaviour in School Children' survey showed that only one-in-five children in European Union member states participated in moderate to vigorous intensity exercise on a regular basis as recommended[3]. This is an alarmingly low rate, and it is therefore not surprising that the promotion of physical activity has moved up on the health agenda[4].

An often-neglected negative side effect of increasing physical activity levels is the associated risk for sports and physical activity related injuries[5-8]. These injuries not only pose a significant burden to the active child, but also to society[9;10]. While injuries are an unavoidable consequence of a physically active lifestyle it is necessary to gain a better understanding of physical activity related injuries in order to minimize risks and to target injury prevention strategies. Injury research in children predominantly focuses on those injuries that occur in an organized setting (i.e. physical education (PE) and sports). Children, however, spend a relatively large amount of their time in unorganized physical activities, i.e. free play[8]. Another potential source of childhood injuries is participation in active commuting[11]. Not only are these four different physical activity behaviours the subject of active lifestyle interventions in children, evidence suggests that injury patterns also vary between these four physical activity behaviours[7;8].

Descriptive information about the magnitude of the association between the different physical activity behaviours and injury risk will be helpful for the development of successful injury prevention messages and strategies[12]. To further target injury preventive efforts, it is helpful to identify those children who are at increased injury risk. Therefore, the aim of this review was to summarize the available literature on the risks associated with overall physical activity, as well as the four main physical activity behaviours in children. In addition, the available literature was searched for potential subgroups of children who are at increased risk for physical activity related injuries.

Methods

Three electronic databases were systematically searched (Embase, PubMed and SPORTDiscus). Search terms were a combination of three elements,: (a) child (i.e. child, schoolchild, youth), (b) injury (i.e. injury, wound, fracture) and (c) sports and physical activity (i.e. sports, movement, walking). All keywords corresponding with the search elements were used as thesaurus terms (MeSH for PubMed, Emtree for Embase), title words and abstract words in all databases. Furthermore, reference lists of related reviews were checked and personal files of authors were searched for useful references. For sports, numerous studies are available on injury risk within a specific sport discipline[13;14]. However, very few studies describe the overall injury risk of 6 to 12 year old children active in sports. While injury incidence rates vary widely between different sports, it was decided to include only studies that reported on overall sports related injuries, i.e. studies that were not restricted to a single sport discipline. Since injury patterns vary over time[15], it was decided to include only studies published after January 1st, 2000. Searches were conducted up to August 2014.

Different physical activity behaviours can be recognized in children when compared to adults. In adults, sports are usually considered as part of leisure time physical activity [16], whereas in children these are two distinct physical activity behaviours. It has been mentioned before that children spend a lot of their time in unorganized leisure time physical activity [8]. Since children are likely to behave differently in an organized and supervised setting (sports) than in an unorganized setting (outdoor play), these two physical activity behaviours were regarded separately.

Papers were included if they met all of the following inclusion criteria. Papers had to: (a) be published in a Dutch, English or German peer-reviewed journal; (b) include healthy children between 6 and 12 years of age; (c) report injuries related to overall physical activity, or to any of the four physical activity behaviours (i.e. active commuting, leisure time physical activity, PE or sports); and (d) report the amount of physical activity exposure.

Title and abstract of all potentially interesting studies were screened; full text articles were retrieved in case of uncertainties. The final inclusion of studies was made after reading full text versions. The following data from included studies were then extracted: study type, population details (age, country, sample size), measure and assessment of physical activity exposure, definition and assessment of injury and outcomes of the study.

Table 2.1: Risk of bias assessment (based on Lopes et al.[17]).

Criteria	Sundblad et al. 2005[18]	Spinks et al. 2006 [19;20]	Schofield et al. 2007[21]	Schmikli et al. 2009[22]	Verhagen et al. 2009[5;7;8]	Gropp et al. 2013[11]	Martin-Diener et al. 2013[23]	Jespersen et al. 2014[24]	% studies with 'yes' response
Is a clear description of the subject demographics within the study population given?	0	1	0	0	1	1	1	1	63
Was the inclusion of participants random or was data collection within the entire target population?	1	1	1	1	1	UD	1	0	75
Was there a prospective design?	0	1	0	0	1	0	0	1	38
Was the duration of data collection appropriate? *For prospective studies at least 6 months follow-up, for retrospective studies up to 12 months recall period.*	1	1	0	1	1	1	1	1	88
For prospective studies, was the frequency of measurement during follow-up mentioned?	NA	1	NA	NA	1	NA	NA	1	100
Was a definition for injury given?	1	1	1	1	1	1	1	1	100
Was a definition of risk exposure given?	0	1	1	1	1	1	1	1	88
Were seasonal changes in risk exposure taken into account?	NA	UD	UD	UD	1	0	UD	0.5[a]	21
Was data analysis conducted in at least 80% of the included subjects?	1	1	1	1	1	0	0	UD	75
Total score (%)	57	89	50	63	100	50	63	72	

Possible responses: 1=yes; 0=no; UD=unable to determine (0); NA=not applicable

[a] Seasonal changes were taken into account for sports and physical education, not for leisure time physical activity.

Two reviewers independently assessed risk of bias (JN and EV). Since no validated risk of bias assessment for this specific type of injury research was available, a checklist was developed based on one used in a comparable review on running related injuries[17]. The checklist contained nine items and evaluated the risk of bias in subject selection, design used, reporting of outcome measures and analysis (Table 2.1). The bias assessment was expressed as a percentage of the maximum score; the risk of bias was considered low when the score was above 75%.

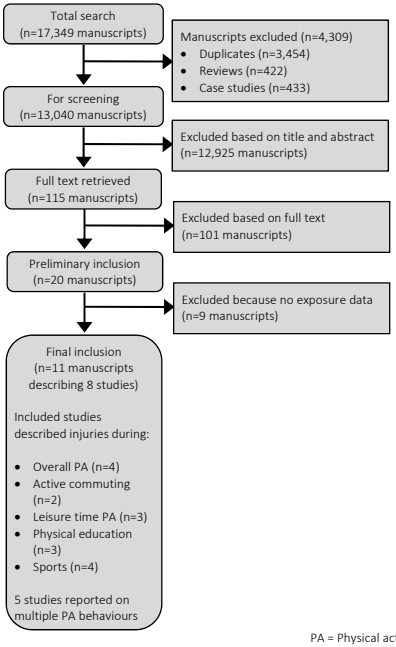
Results

Literature Search

The combined search resulted in a total of 17,349 records. After reading all titles, the full text of 115 manuscripts was retrieved. Six additional manuscripts were identified after manually searching references and personal files. Hundred and one manuscripts were excluded after reading the full text. This resulted in the preliminary inclusion of 20 manuscripts, of which 9 were eventually excluded because of the absence of exposure data (Figure 2.1).

The final search yielded 11 manuscripts, in which eight studies were described. Three studies contained multiple physical activity behaviours[7;19;24]. The final search included four studies reporting on overall physical activity related injuries, two studies reporting on active commuting, three studies reporting on leisure time physical activity related injuries, three studies reporting on PE related injuries and four studies that reported on sports related injuries. A description of included studies is given in Table 2.2. The results of the study by Spinks et al.[19;20] were described in two manuscripts. In one manuscript, results were reported for children aged 5 to 12 (i.e. leisure time physical activity related injuries), while in the other manuscript results were presented separately for 7 to 9 year old and 10 to 12 year old children (i.e. overall physical activity related injuries and sports related injuries). The separate results for the different age categories were included as two separate groups in this review. The results of the study of Verhagen et al.[7] were described in three separate manuscripts[5;7;8]. Risk of bias was assessed for each of the eight studies. Where multiple manuscripts were included, the risk of bias was assessed using the combined information of the respective manuscripts. Meta-analysis could not be performed due to the low number of unique studies for each physical activity behaviour, and the diversity in methodology between studies.

Figure 2.1: Flowchart of manuscript inclusion.



PA = Physical activity

Table 2.2: Description of included studies.

Study	Study design	Population	Exposure	Injury	Outcome [injury incidence dencity (% medically treated)]
Sundblad et al. 2005[18]	Cross sectional	Age: 9, 12 & 15 yrs Country: Sweden N: 1,259	M: Hours PE A:Teacher report	D: Traumatic incident , resulting in medical attention by a school nurse A: Self-report; 10-14 week recall	PE 2.2 (100)
Spinks et al. 2006 [19,20a]	Prospective cohort	Age: 4-12 yrs Country: Australia N: 767 Age: 7-9 yrs N: 326 Age: 10-12 yrs N:213	M: Hours of PA A: Parental report, 7-day activity diary	D: Incident severe enough for first aid treatment to be sought A: Parental report, every 2 months	LPA 0.50 (30) Overall PA 0.52 (29) Sports 0.47 (43) Overall PA 0.59 (36) Sports 0.68 (50)
Schofield et al. 2007 [21]	Ecological analysis	Age: 5-17 yrs Country: New Zealand N: 32,973 (721 schools)	M: Commuting to school A: Self report	D: Incident for which an insurance claim was filed. A: Claims in the New Zealand Accident Compensation Corporation	Active commuting 0.22 (100)
Schmikli et al. 2009 [22]	Cross-sectional	Age: 4-17 yrs Country: The Netherlands N: 433	M: Sports exposure per week A: Method not provided	D: Physical damage as a result of a sudden event during sports or gradual process related to sports A: Retrospective proxy report with an average recall period of 3.5 months	Sports 1.28 (48)
Verhagen et al. 2009 [5,6,7]	Prospective cohort	Age: 10-12 yrs Country: Netherlands N: 995	M: Hours of PE/sports/LPA per week; A: Self-report, one week recall	D: Registration of injuries that caused the child to stop his/her current activity A: Weekly self-report	Overall PA 0.48 (40) LPA 0.39 (44) PE 0.50 (42) Sports 0.66 (33)
Gropp et al. 2013 [11]	Cross-sectional	Age: 11-15 yrs Country: Canada N: 19,576	M: Active transport to and from school A: Self-report	D: Injuries that required medical attention A: Retrospective self-report with a 12 months recall period	Active commuting 0.34 (45)
Martin-Diener et al. 2013 [23]	Cross-sectional	Age: 7-9 yrs Country: Switzerland N: 249	M: Hours of moderate to vigorous PA A: Accelerometers	D: Injury treated by medical professional or guardian A: Retrospective parental report with a 12 months recall period	Overall PA 0.40 (68)
Jespersen et al. 2014 [24]	Prospective cohort	Age: 6-12 yrs Country: Denmark N: 1,259	M: Hours of PE/sports/overall PA A: Overall PA by accelerometers, sports and PE by self-report	D: Clinical examination of medical professional after pain was reported by the parent A: Weekly by SMS-track	Overall PA 0.56 (100[b]) LPA 0.57 (100[b]) PE 0.14 (100[b]) Sports 1.57 (100[b])

M=measure; A=assessment; D=definition; yrs=years of age; N=number; PA=physical activity; PE=physical education; LPA=leisure time physical activity; hrs=hours. [a] In Spinks et al.2006[19], results are described separately for two age groups. In Spinks et al. 2006[20], results are described for the complete cohort. [b] Injuries were clinically diagnosed but not medically treated.

Risk of bias assessment

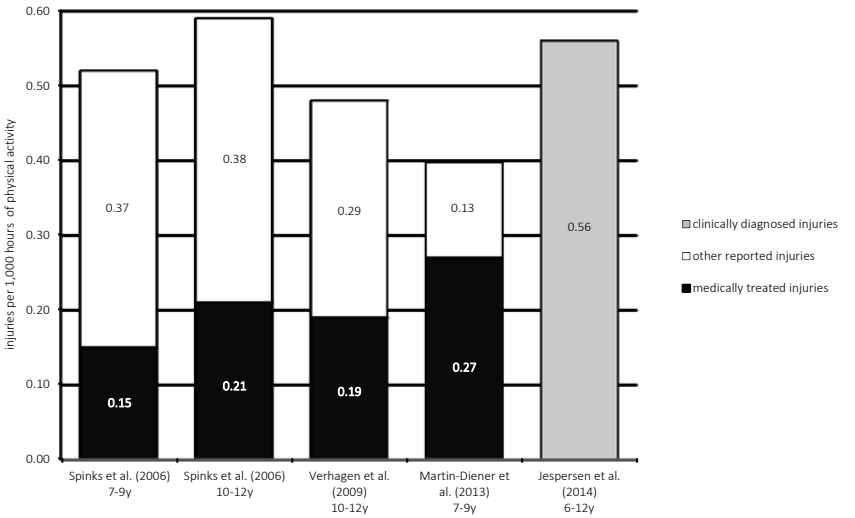
The agreement between reviewers was 77.8%. Differences in scoring were discussed between reviewers. The final results of the bias assessment are displayed in Table 2.1. Two studies had a score of over 75% and were thus considered to have a low risk of bias[7;19]. Three of the included studies used a prospective design[7;19;24]. The used definition of exposure to physical activity was described in 7 out of 8 studies[7;11;19;21-24], and an injury definition was given in all studies[7;11;18;19;21-24]. The criteria for inclusion of participants caused concern about bias in two studies[11;24], and most studies employed an appropriate duration of data collection (7 out of 8 studies[7;11;18;19;22-24]; i.e. at least 6 months for prospective studies or a maximum of 12 months recall in retrospective studies). Three studies did not clearly describe participants[18;21;22]. Seasonal changes were fully accounted for in one study[7], and partially in another study[24].

Overall physical activity related injuries

As shown in Table 2.2, the included studies used 'time-loss' or 'medical attention' definitions for injury. This implies that the reported injuries are primarily of acute nature, and overuse problems may have been underreported. It was not possible to differentiate acute from overuse injuries in the reported data and we were therefore able to provide only overall injury incidence rates.

Four of the included studies reported on injuries sustained during overall physical activity, i.e. including different physical activity behaviours[7;19;23;24]. Results of one of the studies are described separately for two age categories[19]. The risk of bias assessment revealed that bias was low for two of the studies[7;19]. One study included 7 to 9 year old children[23], one study included 10 to 12 year old children[7], one study included both 7 to 9 year old and 10 to 12 year old children[19] and one study reported on children aged 6 to 12[24]. Results are displayed in Figure 2.2. Reported injury incidence rates ranged from 0.40 to 0.59 injuries per 1,000 hours of physical activity participation. Injury incidence rates for 10 to 12 year old children were almost identical when only medically treated injuries were taken into account (i.e. 0.19 and 0.21 injuries per 1,000 hours of physical activity participation, Figure 2.2)[7;19]. In 7 to 9 year old children, however, incidence rates of medically treated injuries varied between 0.15 and 0.27 injuries per 1,000 hours of physical activity participation[19;23]. 0.56 clinically diagnosed injuries per 1,000 hours were reported in children aged 6 to 12 years[24].

Figure 2.2: Reported injury incidence rates expressed per 1,000 hours of overall physical activity.



Injuries during active commuting

Two studies were identified that had reported on injuries associated with active commuting (i.e. cycling or walking)[11;21]. A recent study reported that 11 to 15 year old children had sustained 0.34 injuries per 1,000 hours of active commuting[11]. When only medically treated injuries were taken into account, the injury incidence rate was 0.15 injuries per 1,000 hours of active commuting. The other study that employed an ecological analysis, using data from an accident compensation commission database, reported 0.22 medically treated injuries per 1,000 hours of active commuting[21] (Figure 2.3). When comparing walking for transport with cycling for transport, Schofield et al.[21] reported significantly lower incidence rates for walking than for cycling (0.0290 versus 0.1943 per 1,000 hours of active commuting).

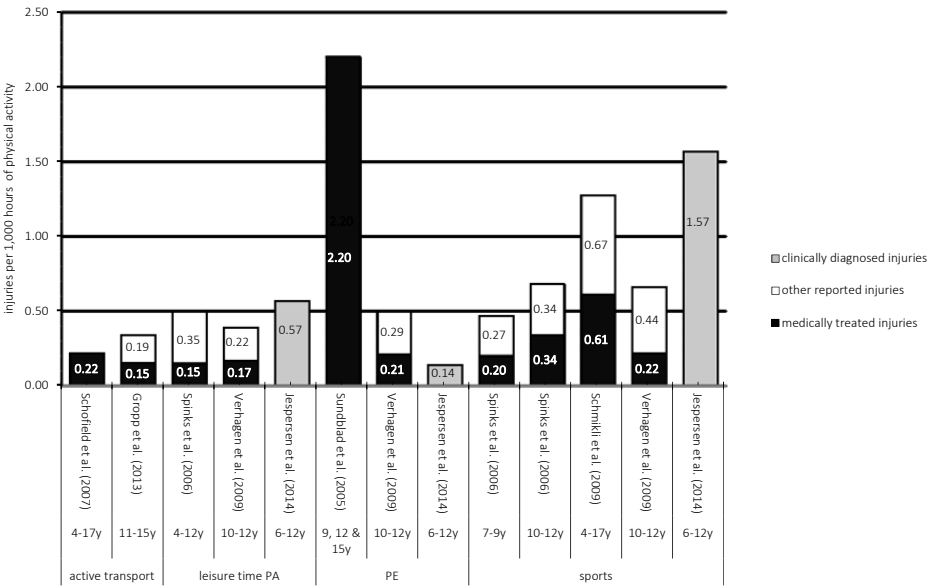
Injuries during PE

Injury incidence rates during PE classes were reported on in three studies[7;18;24]. The results varied substantially. One study reported 2.2 injuries per 1,000 hours of PE[18], while the other studies reported an injury incidence rate of 0.50 injuries[7] or even 0.14 injuries per 1,000 hours of PE[24]. When, in the case of the study of Verhagen et al.[7], only medically treated injuries were taken into account the injury incidence rate was 0.21 injuries per 1,000 hours of PE (Figure 2.3).

Leisure time physical activity related injuries

The majority of studies on leisure time physical activity related injury reported on injuries resulting from the use of playground equipment (e.g. climbing frames, monkey bars, and trampolines). Three studies were identified that reported in general on injuries sustained during leisure time physical activity [7;20;24]. The risk of bias for two of these studies was considered low[7;20]. Although absolute numbers of reported injuries were high, the injury incidence rates, as reported by the three studies, varied from 0.39[7] to 0.57[24] injuries per 1,000 hours of leisure time physical activity (Figure 2.3). When only medically treated injuries were taken into account, differences between reported injury incidence rates were very small for two of the studies (0.15 v.s. 0.17 injuries per 1,000 hours of leisure time physical activity)[7;20], the third study only consisted of clinically assessed injuries[24].

Figure 2.3: Reported injury incidence rates expressed per 1,000 hours of active transport, leisure time physical activity, physical education and sports.



Sports related injuries

Four studies were identified that reported on overall sports related injury risk[7;19;22;24]. Results of one of the studies are described separately for two age categories[19]. Risk of bias was low in two studies[7;19]. The injury incidence rates reported by Schmikli et al.[22] and Jespersen et al.[24] were almost twice as high as those reported in the other two studies[7;19](Figure 2.3). When only considering medically treated injuries, this gap became larger (0.61 vs 0.20 – 0.34 medically treated injuries per 1,000 hours sports participation) (Figure 2.3)[7;19;22]. For an interpretation of these results, it is important to bear in mind that the absolute number of injuries used for calculating injury incidence rates was low in the study that reported injury incidence rates in two separate age categories (8 and 10 injuries, respectively)[19].

Injuries in subgroups

Two studies were identified that had reported on injury incidence rates for subgroups of subjects[5;23] (Table 2.3). Despite varying definitions of an injury, reported sex differences in injury incidence rates per 1,000 hours of physical activity were comparable. Both studies reported higher incidence rates for girls compared to boys. No differences were reported by overweight status in any of the studies.

Results of other subgroup analyses were conflicting. Verhagen et al.[5] reported that the least active children were reported to have the highest injury incidence rate. This finding was, however, not confirmed by the study of Martin-Diener et al.[23]. On the other hand, Martin-Diener et al.[23] reported higher injury incidence rates for children with low levels of aerobic fitness.

Table 2.3: Injury rates for potential risk factors for overall physical activity related injuries.

Study	Verhagen et al. Injuries per 1,000 hours of PA	Martin-Diener et al. Injuries per 1,000 hours of PA
Sex		
Boys	0.35	0.38
Girls	0.57*	0.58*
Overweight	Q_1 = 0.44	No = 0.40
	Q_4 = 0.40	Yes = 0.59
PA exposure	Q_1 = 0.72**	T_1 = 0.48
	Q_4 = 0.35	T_3 = 0.39
Motor performance fitness test	T_1 = 0.47	
	T_3 = 0.47	
Coordination[a]		Low = 0.49
		Normal = 0.35
		High = 0.57
20m shuttle run test		T_1 = 0.64***
		T_2 = 0.30
		T_3 = 0.36

*p < 0.05 girls vs boys; **p < 0.05 Q1 vs Q4; ***p < 0.05 T1 vs T2'; PA=physical activity; Q_1=first quartile, Q_4=last quartile, T_1=first third, T_2=second third, T_3=last third. [a]Körperkoordinationstest für Kinder KTK (total body coordination).

Discussion

The current review was performed to summarize the available literature on the risks associated with both overall physical activity and the four main physical activity behaviours (i.e. active commuting, leisure time physical activity, PE and sports) in 6 to 12 year old school children. Only 8 studies could be included, which meant that some study characteristics could have biased comparisons and the generalizability of findings could have been reduced; e.g. cultural differences in injury reporting, lack of studies from low or middle income countries, lack of information on severity of injuries. In addition, the methodological quality of studies included varied greatly, and the risk of bias was determined to be low in only two of the studies. Despite most studies included both medically treated and untreated injuries into their analysis, different definitions were used for injuries that were not medically treated. The assessment measures used for exposure to physical activity warrant caution. Exposure was usually based on few data points, which influences reliability. Furthermore, physical activity patterns, especially active commuting and leisure time physical activity, are subject to seasonal changes. Adjustments for seasonal changes were usually not accounted for.

For overall physical activity, incidence rates of medically treated injuries ranged from 0.15 to 0.27 injuries per 1,000 hours participation[7;19;23]. One study reported 0.56 clinically diagnosed injuries per 1,000 hours of physical activity [24]. The injury

incidence rates related to PE were inconsistent (they varied from 0.14 to 2.20 injuries per 1,000 hours of PE). When considering each of the other three physical activity behaviours, sports came out as most risky (range 0.20–0.67 medically treated injuries per 1,000 hours of sports)[7;19;22] compared to active commuting (range 0.15–0.52 injuries per 1,000 hours of active commuting)[11;21] and leisure time physical activity (range 0.15-0.17 injuries per 1,000 hours of leisure time physical activity)[7;20]. Reported clinically diagnosed injury incidence rates were higher for sports and leisure time physical activity injuries when compared to medically treated injury incidence rates[24]. Subgroup analysis suggested that girls were at increased injury risk. Low levels of physical activity and/or physical fitness seemed to increase injury incidence levels, but the exact mechanisms remain unclear[7;23]. Weight status did not increase physical activity related injury risk.

The variety in reported injury incidence rates can for a large part be explained by differences in injury definitions. As can be seen in Table 2.2 definitions range from 'time-loss' to 'medical treatment at an ER', by which studies report on various selections of the overall sustained number of injuries in a youth population. Nonetheless, employed definitions have in common that they all describe 'time loss' and / or 'traumatic events'. Within these definitions overuse problems are likely to be missed while overuse related problems do not necessarily lead to time loss[25]. Also, it proved impossible to differentiate between acute and overuse injuries in the reported incidence rates. This does not mean overuse injuries are not present in youth physical activity and sports. Consequently, we recommend future studies to employ registrations that are able to validly register overuse problems in youth[26;27].

Although injury incidences expressed per hour of exposure were lower for leisure time physical activity than for sports and comparable to active commuting, the absolute number of injuries occurring during leisure time physical activity was high. In the three studies that reported on PE, leisure time physical activity and sports injuries, 44-86% of all injuries occurred during leisure time. This is understandable because a large proportion of a child's physical activity is spend in unorganized leisure time physical activity [8]. The same phenomenon was observed in adults, where low-risk, but very popular, activities such as gardening, walking and cycling resulted in high absolute numbers of associated injuries[28;29].

Although the differences between reported injury incidence rates may seem large (ranging from 0.14 to 2.20 injuries per 1,000 hours physical activity

exposure), broader ranges have been reported in a systematic review on sports related injuries in youth[14]. 27 studies reported injury incidences ranging from 0.04 to 127.3 per 1,000 hours of exposure. Even when only considering one specific sport, soccer, the injury incidence range was still 0.04 to 75.8 injuries per 1,000 hours of exposure[14].

Some possible explanations for the differences in incidence rates within physical activity behaviours could be identified. First, higher injury incidences of medically treated and clinically diagnosed injuries were reported in both studies with objectively assessed physical activity using accelerometers[23;24]. Self-reported physical activity has been shown to overestimate the amount of physical activity compared to objectively assessed physical activity [30;31]. Thus, an overestimation of exposure in studies with self-reported physical activity would result in an underestimation of incidence rates compared to studies with objectively assessed physical activity. The studies with relatively high reported PE and sports related injury incidence rates differed from those studies with lower incidence rates regarding the inclusion of data of adolescents. This methodological characteristic could have resulted in higher injury incidence rates, because higher age is generally associated with higher injury risk[13;32;33].

The results of the subgroup analysis summarized in the present review suggested that girls were at increased physical activity related injury risk. This is conflicting with previous research that considered boys to be at increased sports related injury risk[13;14]. These contradicting results could be caused by the fact that the studies in question reported injury rates for sport only. Sport is usually organized separately for boys and girls. In the current review we included various modes of physical activity, diluting the sex differences that may exist in sports related injury rates. During leisure time physical activity participation is not sex restricted, and playing together with boys could increase physical activity related injury risk in girls. Also, previous studies[13;14] included adolescent athletes. Sex differences in injury patterns may be more pronounced through the developmental differences in physique after puberty, and during adolescence the physical demands of sports are higher than during childhood further affecting sex differences in injury risk.

The finding that no association between overweight status and injury risk could be reported was consistent with results from two recent studies that reported no association between body mass index and lower extremity injury risk in 7 to 12 year old children[35], and between overweight status and overall injury risk in 4 to 24 year olds[36].

A discrepancy was found with respect to reported injury incidence rates related to motor skills. The trend reported by Martin-Diener et al.[23] that children with a high coordination score were at increased injury risk was not confirmed by Bloemers et al.[5]. The different results could not be explained, other than that two different tests were used to assess motor skills.

Of special concern is the possible increased injury risk for children with low habitual levels of physical activity [5;23]. Results of previous research is also conflicting; In 9 to 16 year old children, screen time was positively associated with forearm fractures, while light intensity physical activities were negatively associated with forearm fractures[34]. In another study in 12 to 16 year old children, aerobic fitness was associated with an increased risk of fractures[37]. This risk was, however, highest in children with low muscle strength[37].

Since children with low levels of physical activity are the primary focus of many physical activity promotion initiatives, it would be interesting for public health to unravel this relationship. This is particularly the case given that a comparable inverse relationship between physical activity and injury risk has been reported in the general adult population. A history of physical inactivity, higher body mass index and low aerobic fitness was reported to contribute to physical training related injuries in military recruits[38]. Comparable associations were reported in a review on running injuries. Pooling of the data according to experience level clearly showed that injury incidence rates per 1,000 hours of running was highest in novice runners and gradually declined when participants became more experienced[39].

Nonetheless, the results of this study should be put in context. Although injury may result from physical activity it should be recognized that the risk and severity of injury due to physical activity at the population level are minimal relative to the clear benefits of physical activity [40]. Action can be taken to minimize the detrimental effects of physical activity, amongst which - in addition to prevention efforts - a stronger emphasis on the promotion of low risk activities should be considered. Active commuting may be one such activity. The health benefits of active commuting have been well described while the risks of injury are regulated and minimal[41;42].

Strengths and Limitations

The major strengths of the this review are that it focussed on children of the general population, on overall and domain specific physical activity and that only

studies reporting on the number of injuries per hour of exposure were included. The current review is, of course, subject to bias. One possible source of bias is the restrictions of the search. A limited number of databases was used, and only peer-reviewed manuscripts that were written in Dutch, English or German were included. This bias was however kept to a minimum by manually searching references of relevant manuscripts and personal files. Since no bias assessment tool was available for this specific research field, a previously used criteria list[17] was adapted. The choice of items is thus, to some extent, arbitrary.

Conclusions

Although the injury incidence rate per 1,000 hours of activity is reported to be lower during leisure time physical activity compared to sports, the absolute number of injuries is comparable in the two domains. Thus, results suggest that injury prevention in children should focus both on sports and leisure time physical activity related injuries. Reported injury incidence rates associated with active commuting are low when compared to the other physical activity behaviours. Results for PE related injuries are conflicting. The comparison of subgroups suggests that injury incidence rates are higher in girls than in boys, that overweight is not associated with increased injury incidence rates, but that children with low levels of physical activity are at increased injury risk.

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